

# Morphological Image Processing

Image Processing

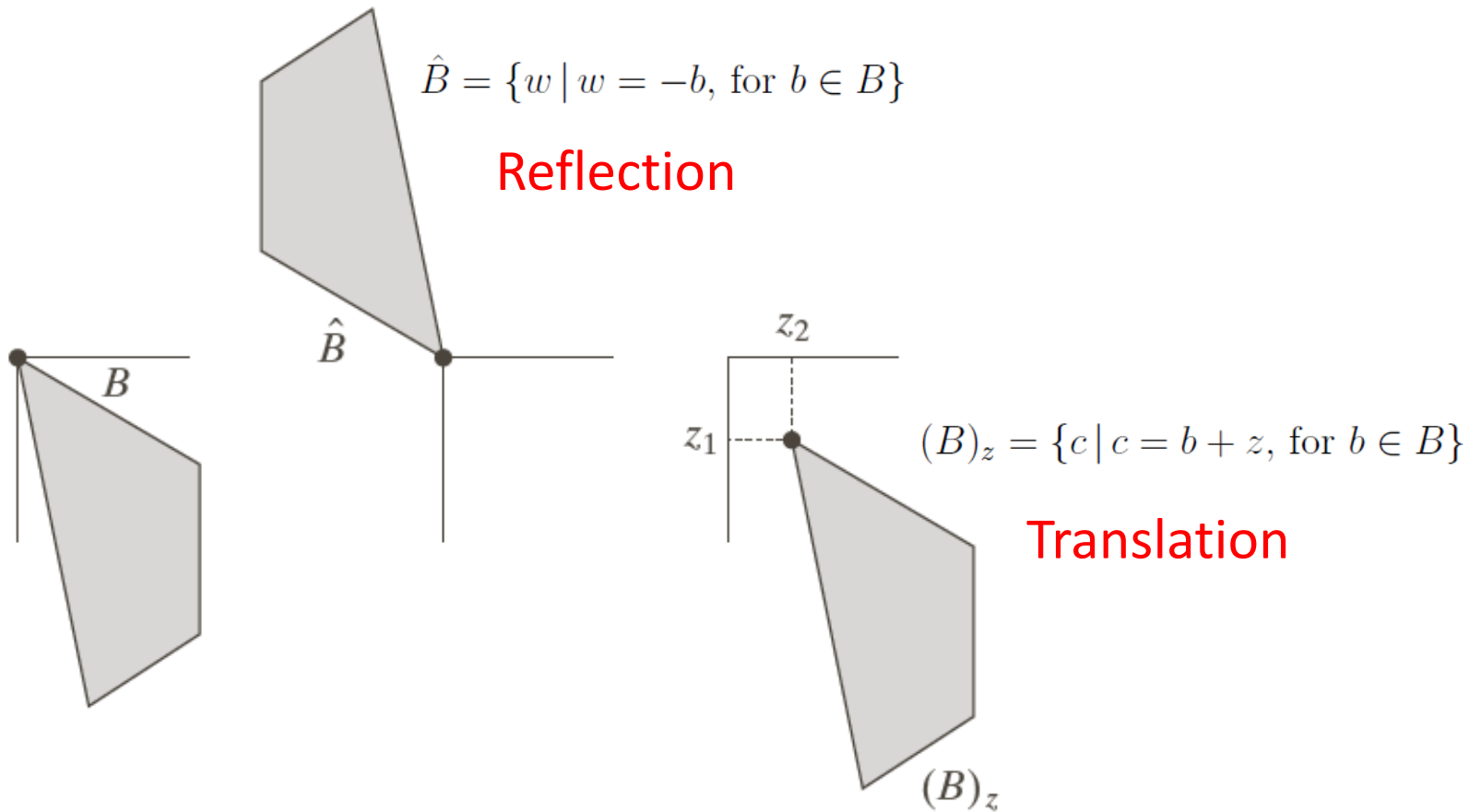
CSE 166

Lecture 15

# Announcements

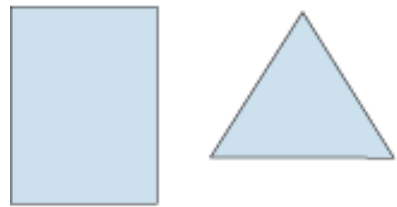
- Assignment 4 is due today, 11:59 PM
- Assignment 5 will be released today
  - Due May 29, 11:59 PM
- Reading
  - Chapter 9: Morphological image processing
    - Sections 9.1, 9.2, 9.3, and 9.5 (through subsection connected components)

# Reflection and translation

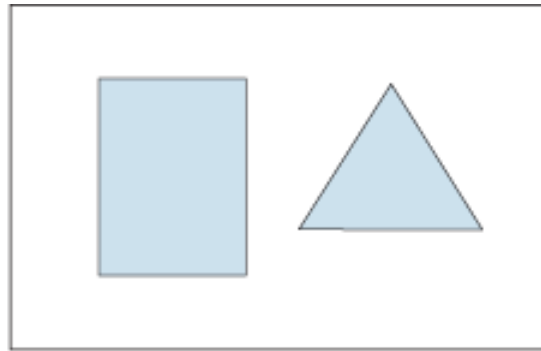


# Sets of pixels: objects and structuring elements (SEs)

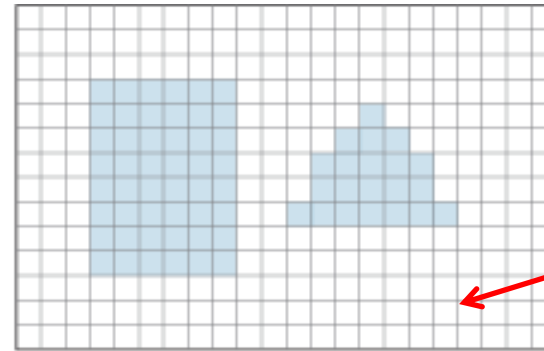
Border of  
background  
pixels  
around  
objects



Objects represented  
as sets



Objects represented as  
a graphical image



Digital image



Structuring element  
represented as a set



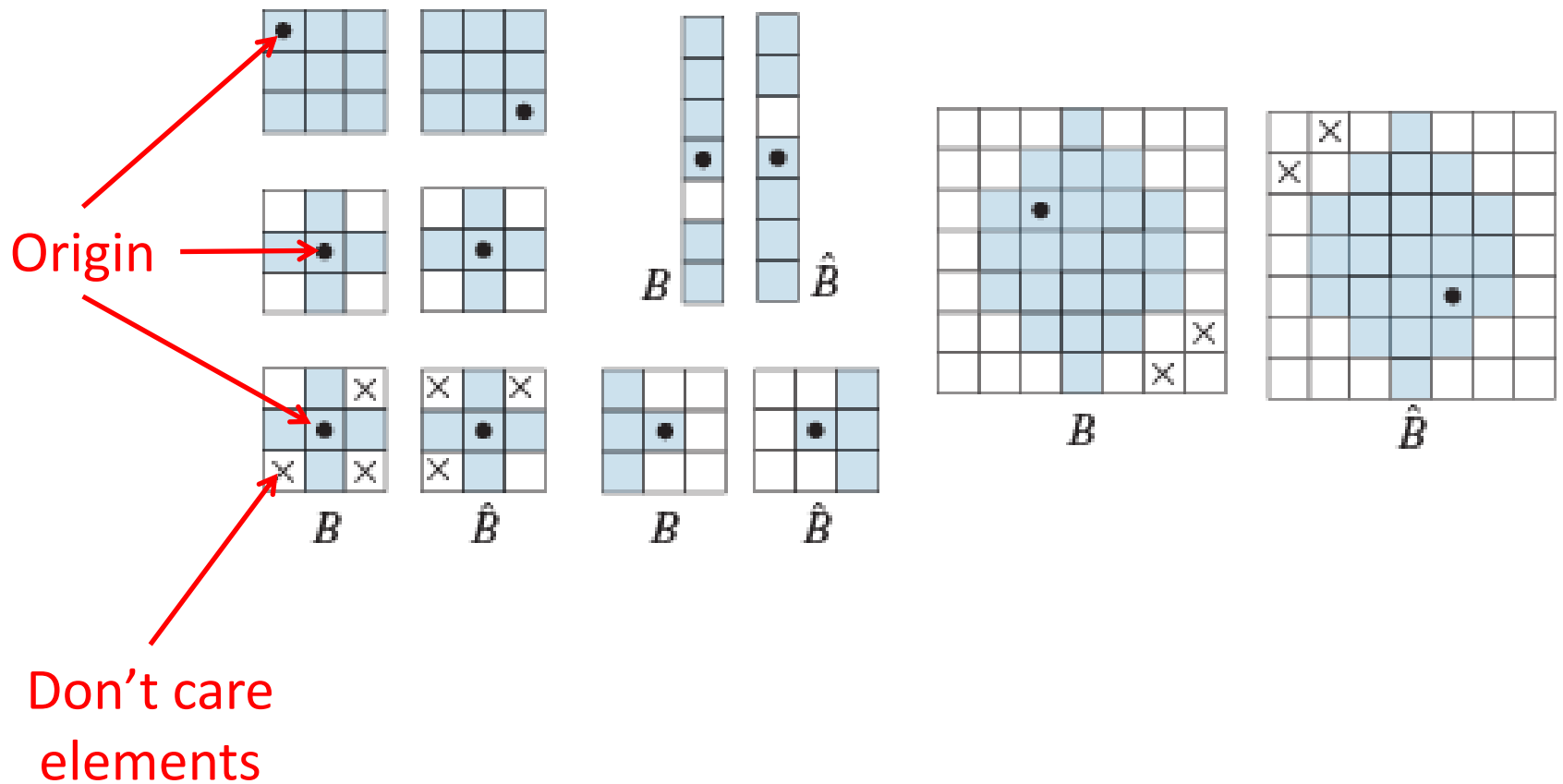
Structuring element  
represented as a graphical image



Digital  
structuring element

Tight border  
around SE

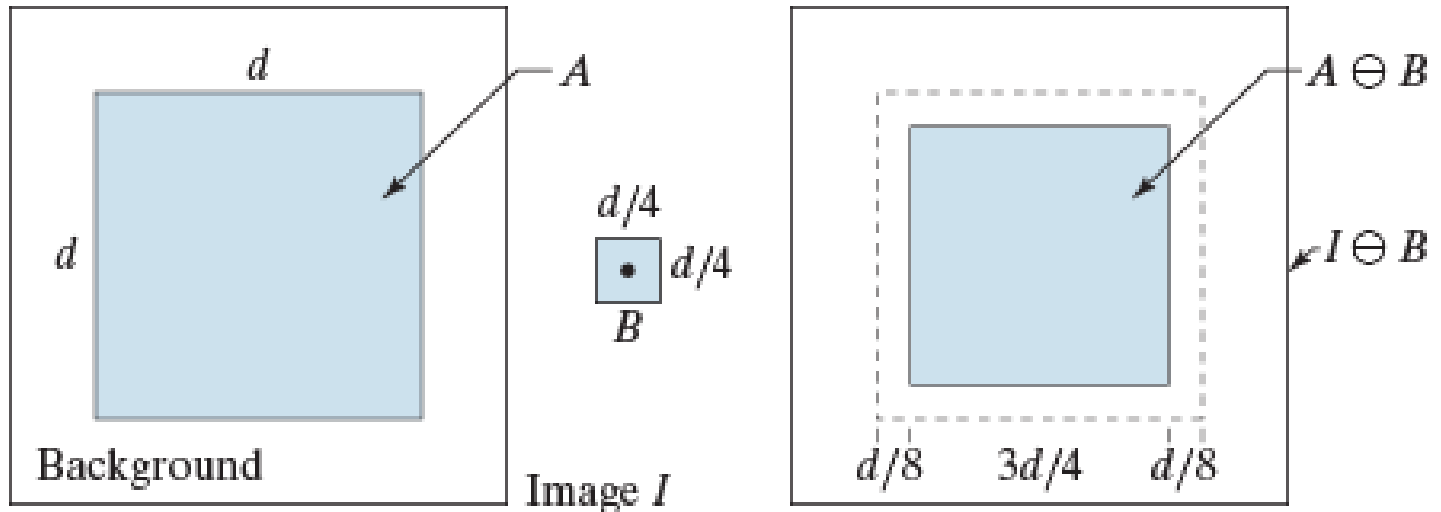
# Reflection about the origin



# Erosion

Example: square SE

$$A \ominus B = \{z \mid (B)_z \subseteq A\}$$



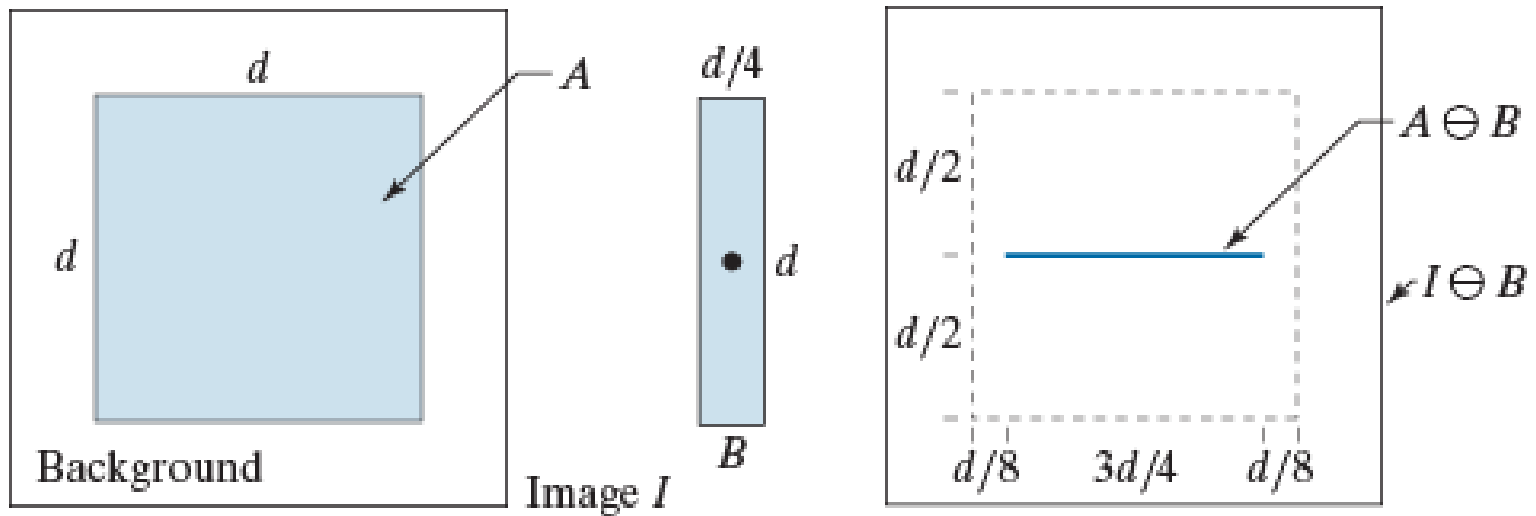
$$I \ominus B = \{z \mid (B)_z \subseteq A \text{ and } A \in I\} \cup \{A^c \mid A^c \subseteq I\}$$

Complement of A  
(i.e., set of elements not in A)

# Erosion

Example: elongated SE

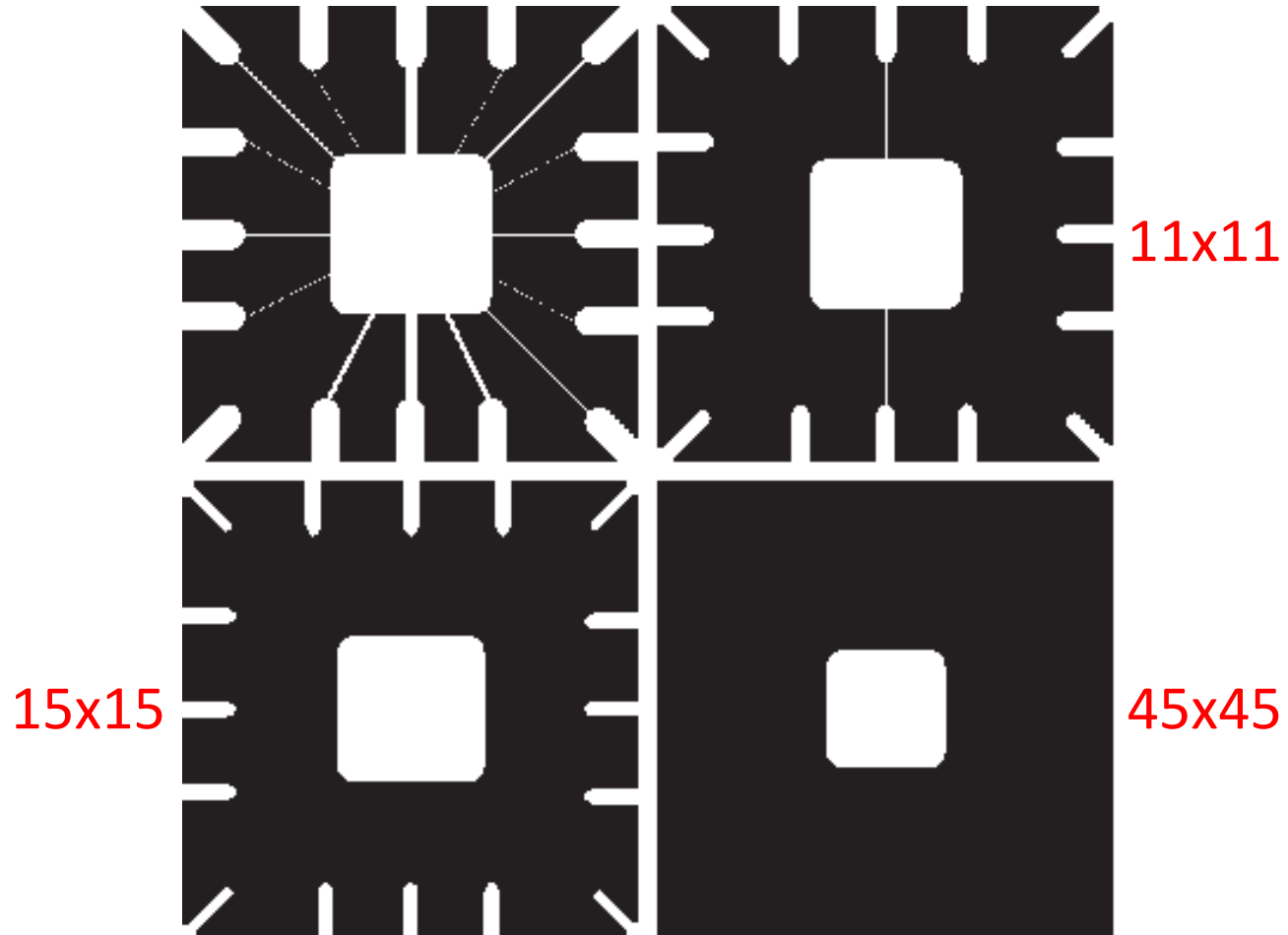
$$A \ominus B = \{z \mid (B)_z \subseteq A\}$$



$$I \ominus B = \{z \mid (B)_z \subseteq A \text{ and } A \in I\} \cup \{A^c \mid A^c \subseteq I\}$$

# Erosion

Shrinks

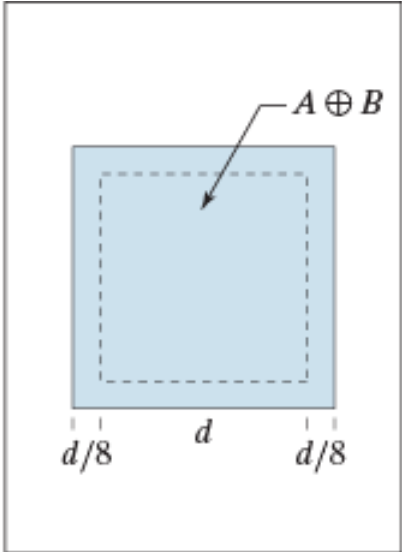
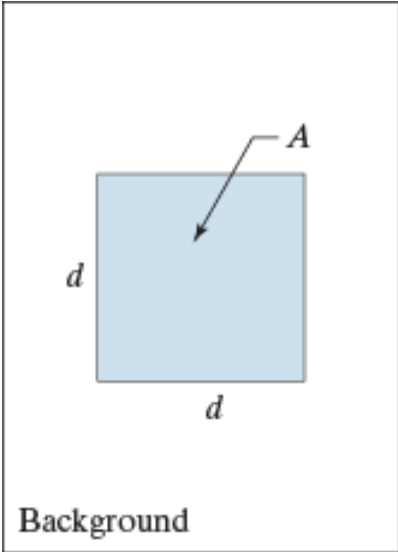




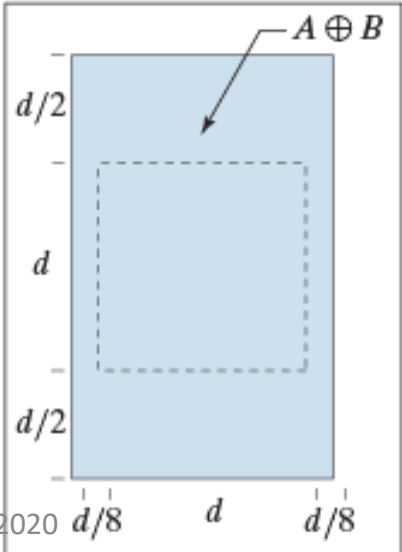
# Dilation

$$A \oplus B = \{z \mid (\hat{B})_z \cap A \neq \emptyset\}$$

Examples



Square SE



Elongated SE

# Dilation

Expands

Historically, certain computer programs were written using only two digits rather than four to define the applicable year. Accordingly, the company's software may recognize a date using "00" as 1900 rather than the year 2000.

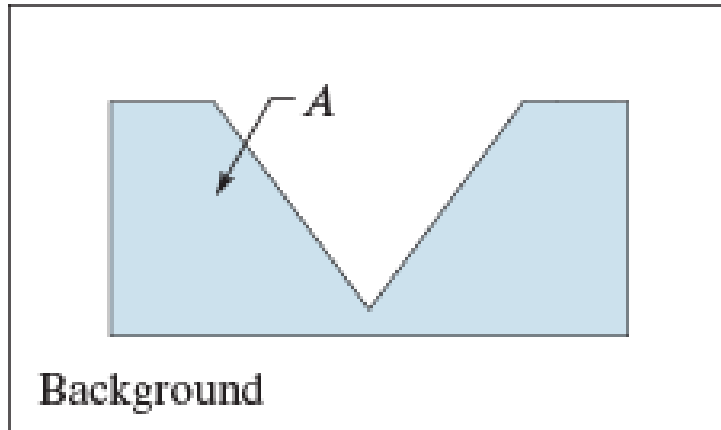


Historically, certain computer programs were written using only two digits rather than four to define the applicable year. Accordingly, the company's software may recognize a date using "00" as 1900 rather than the year 2000.



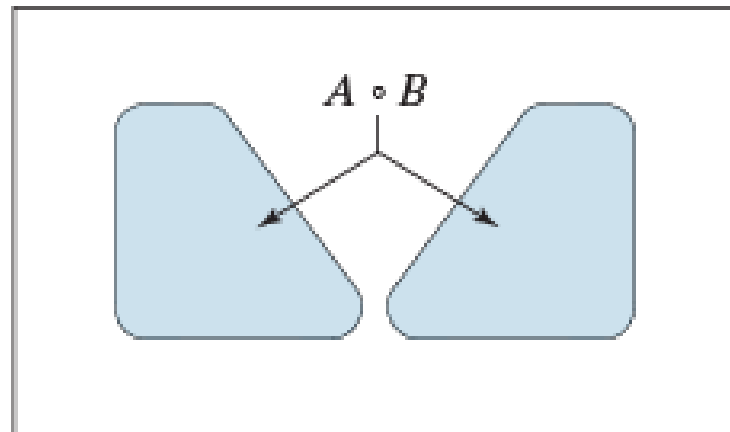
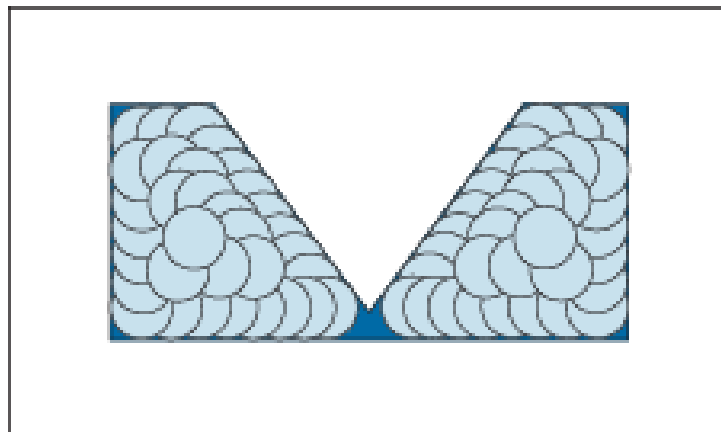
1	1	1
1	1	1
1	1	1

# Opening



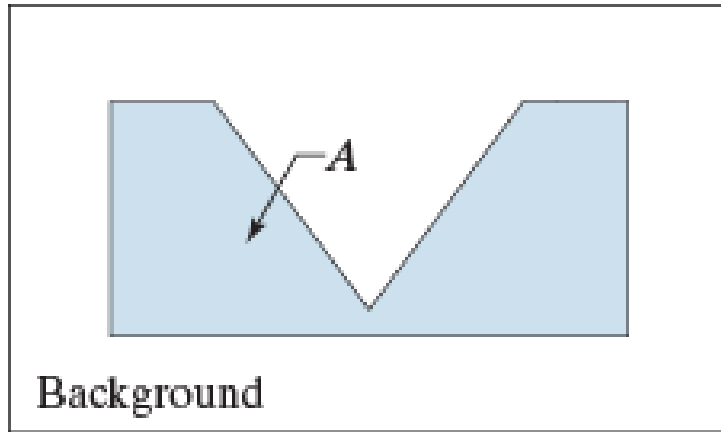
Image,  $I$

$$A \circ B = (A \ominus B) \oplus B$$



Structuring element rolls along **inner** boundary

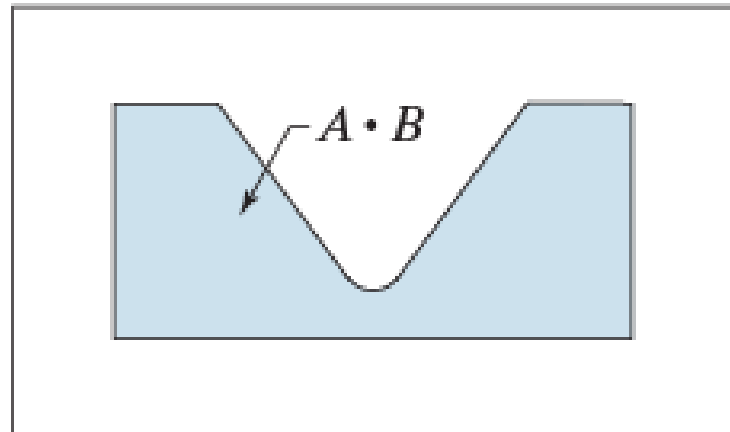
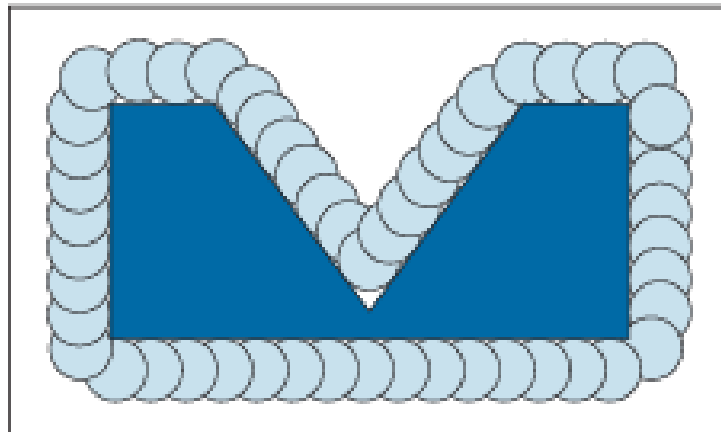
# Closing



Image,  $I$

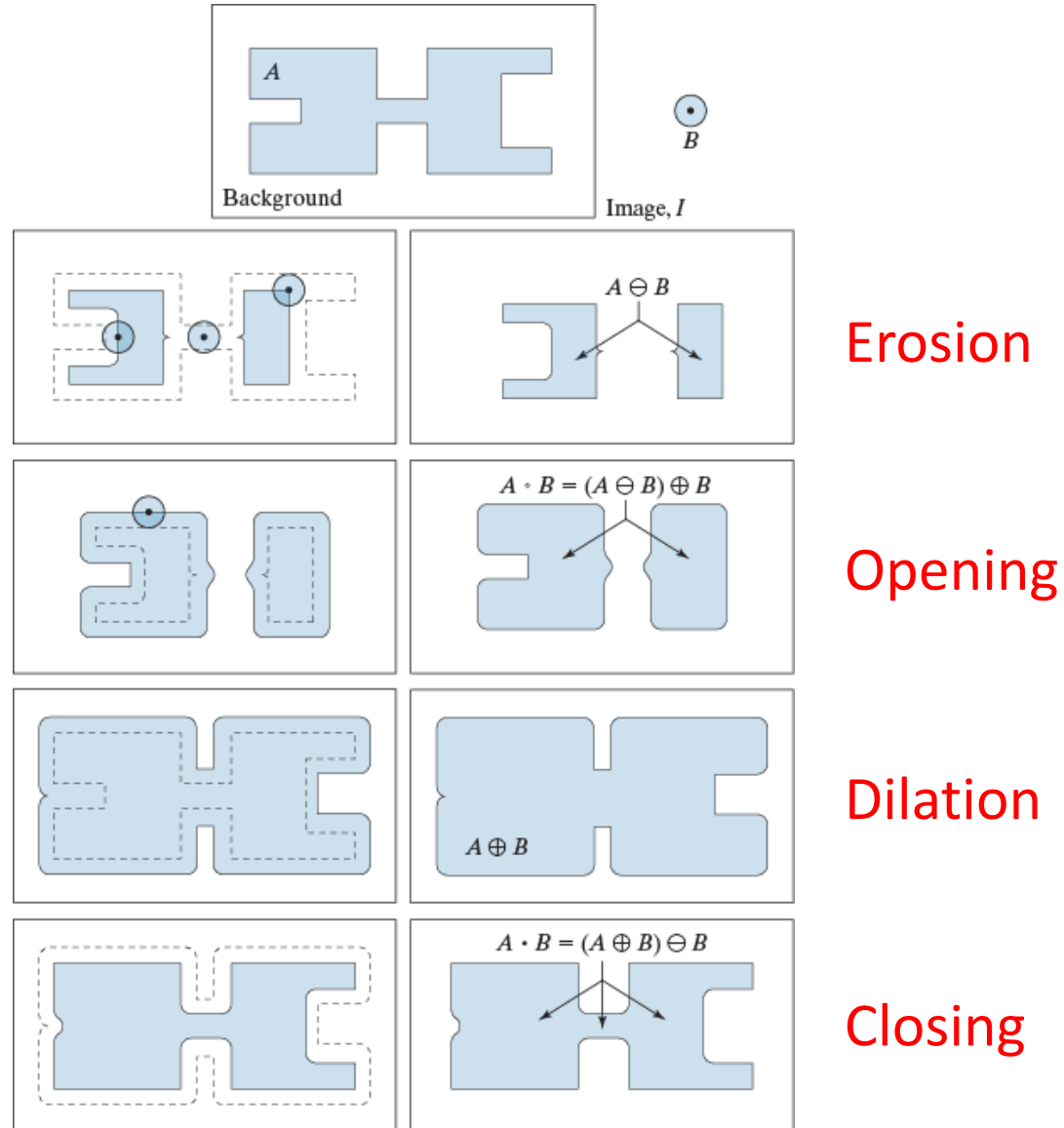


$$A \bullet B = (A \oplus B) \ominus B$$

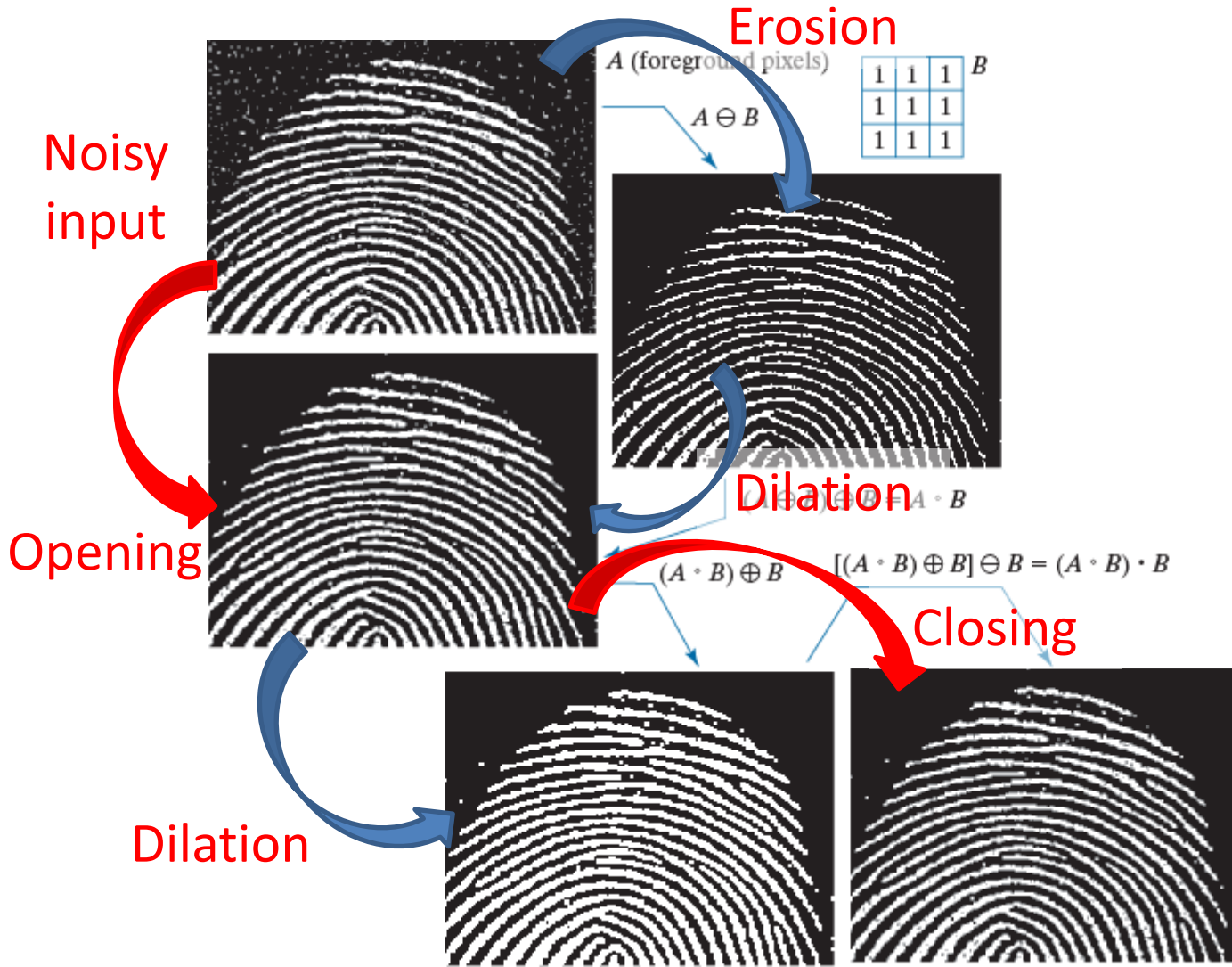


Structuring element rolls along **outer** boundary

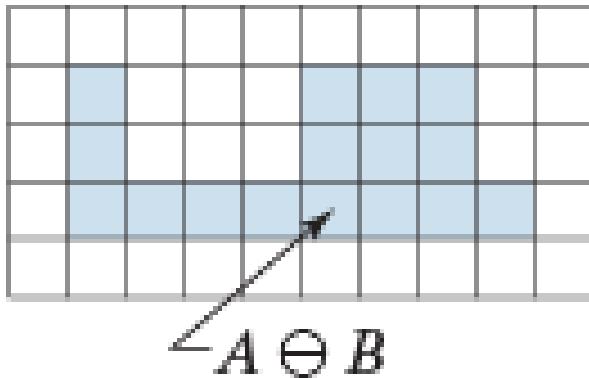
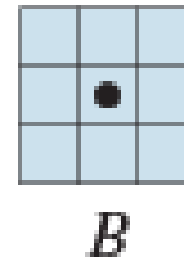
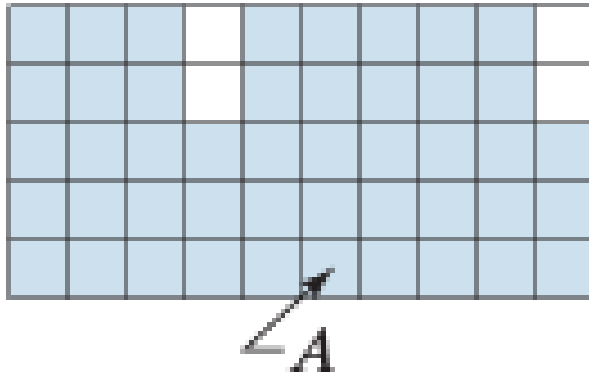
# Opening and closing



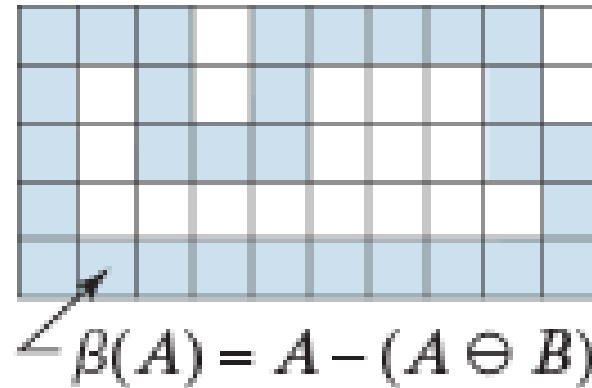
# Morphological image processing



# Boundary extraction

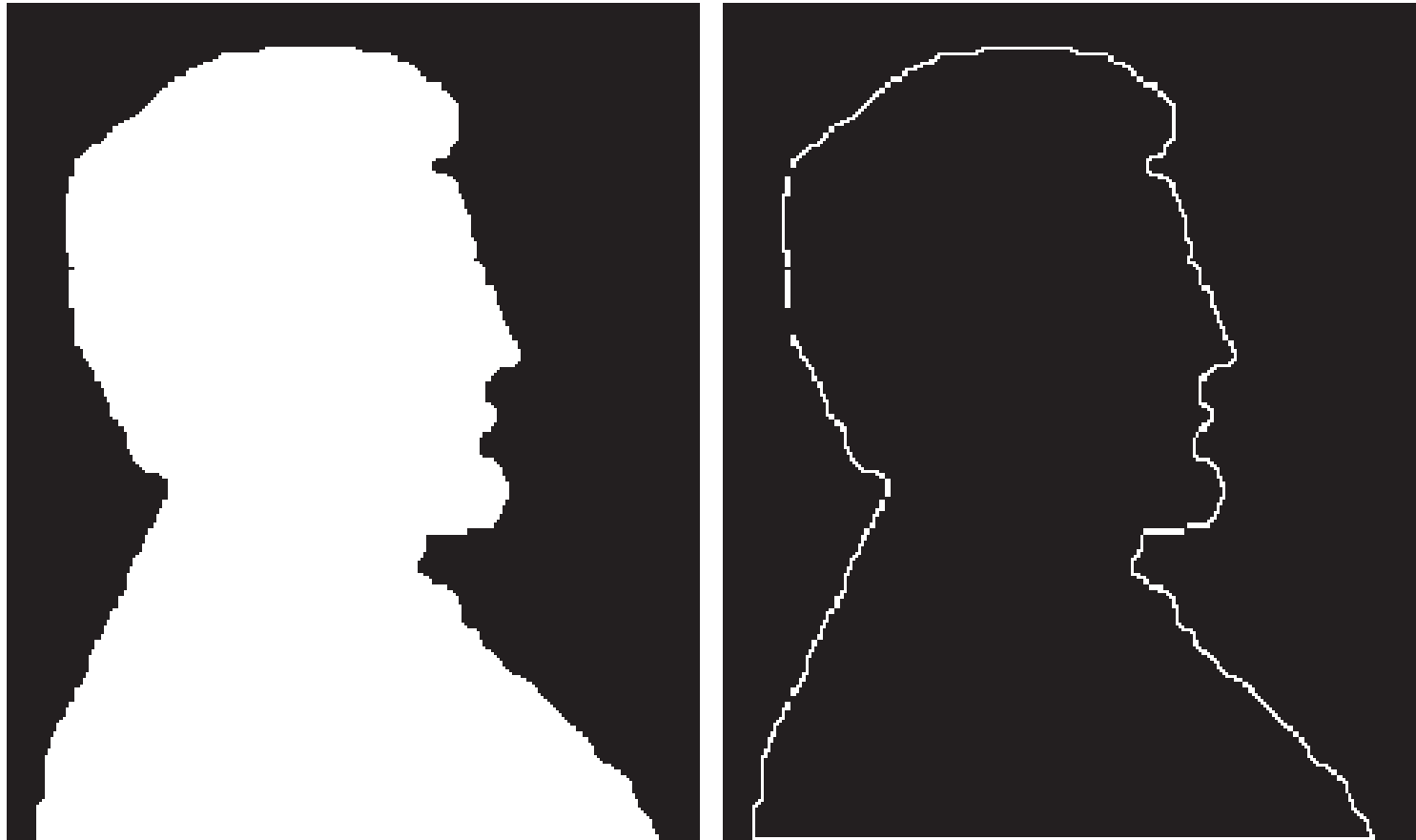


Erosion



Set difference

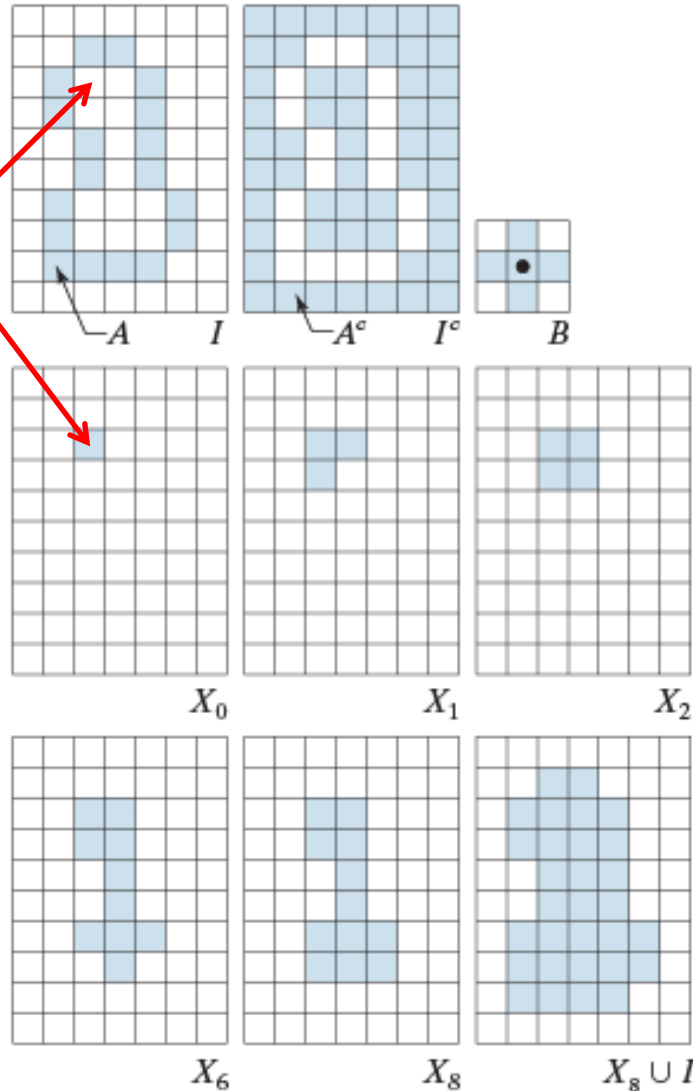
# Boundary extraction





# Hole filling

Given point  
in hole

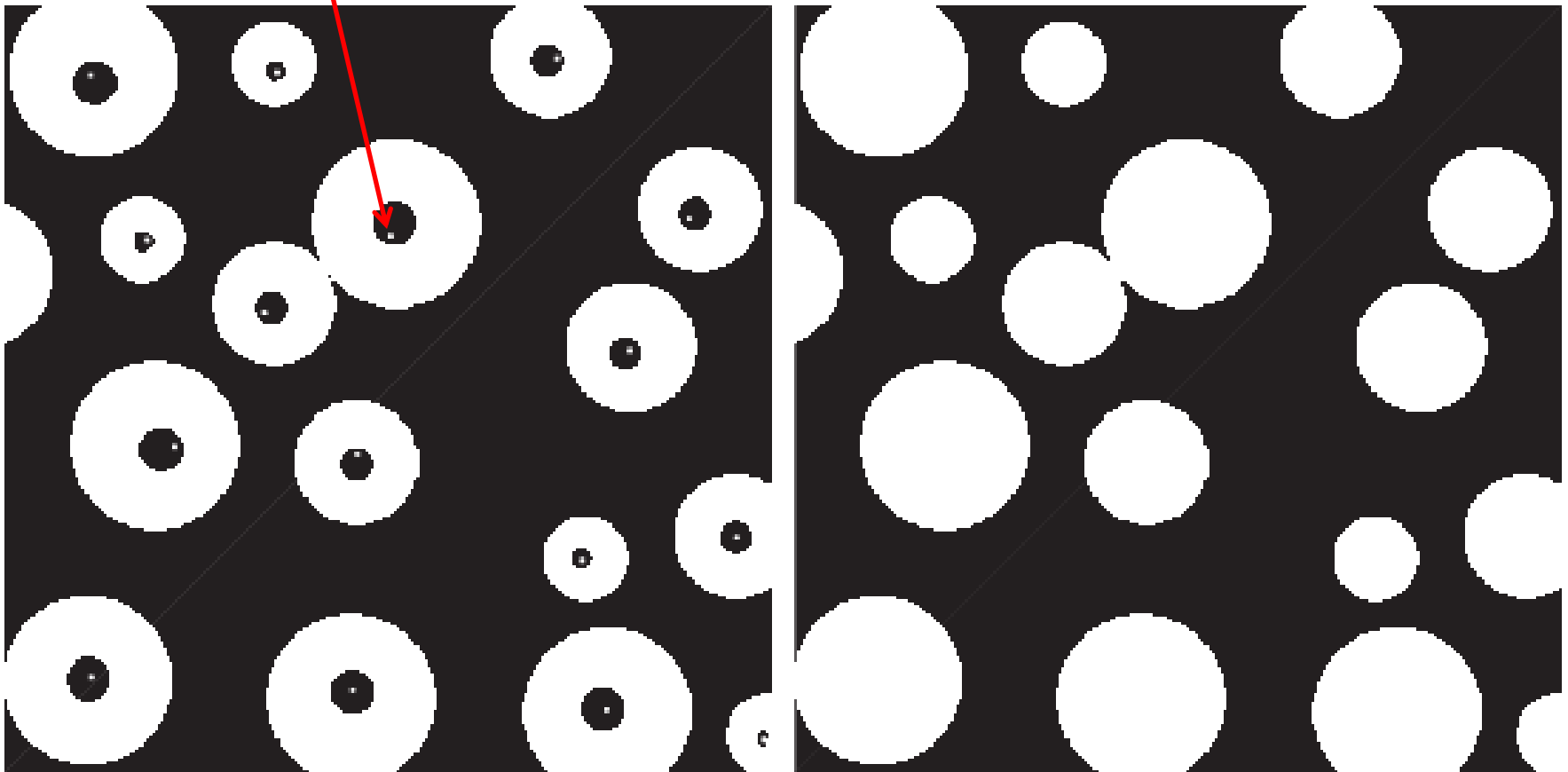


$$X_k = (X_{k-1} \oplus B) \cap A^c \quad k = 1, 2, \dots$$

# Hole filling

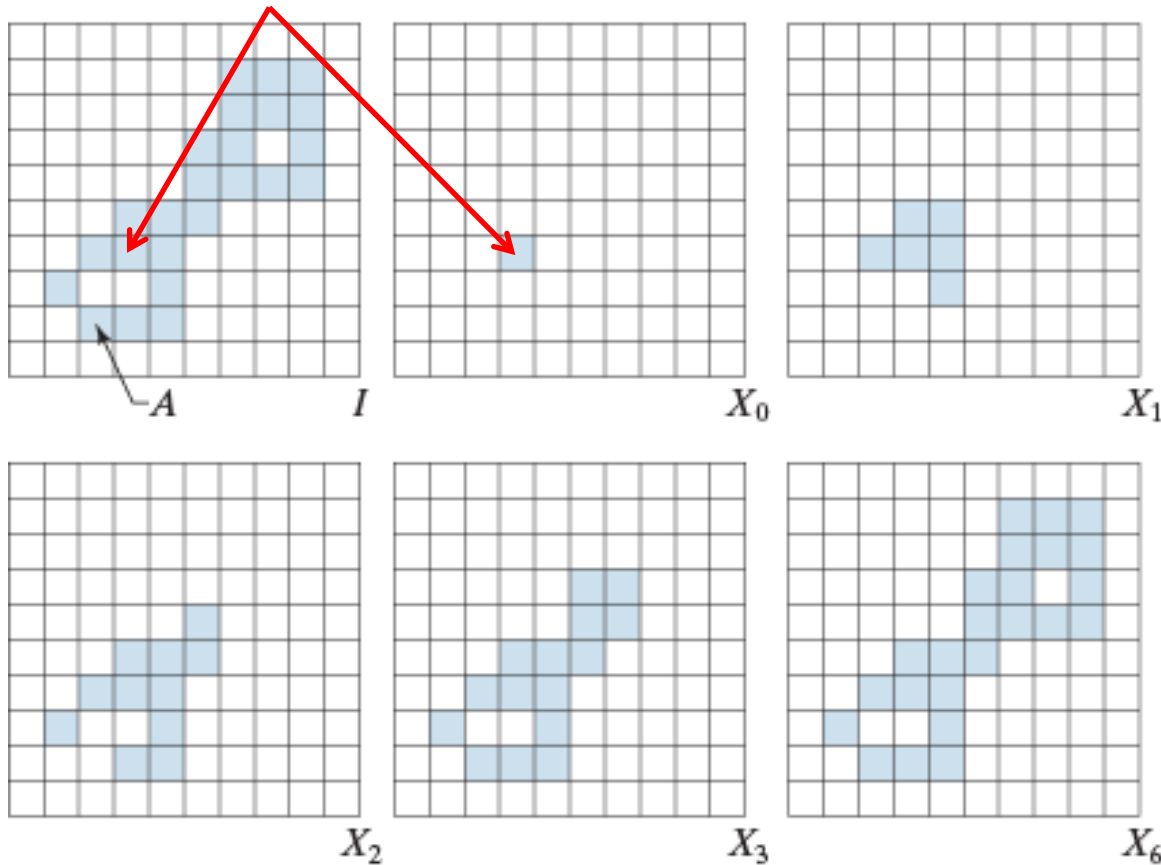
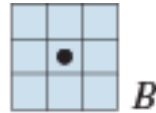
Given points in holes

All holes filled



# Connected components

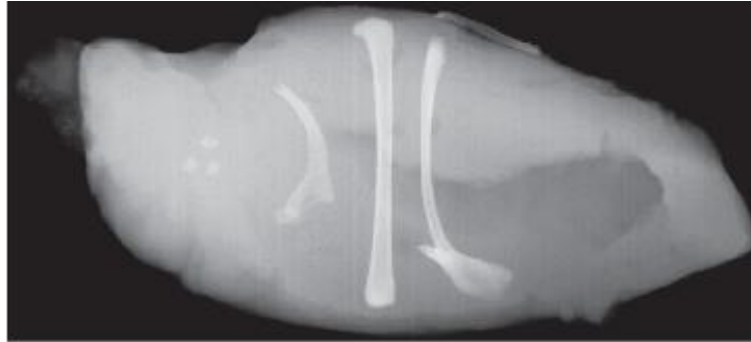
Given point  
in A



$$X_k = (X_{k-1} \oplus B) \cap A \quad k = 1, 2, \dots$$

# Connected components

X-ray image



Threshold  
(negative)



Connected component	No. of pixels in connected comp
01	11
02	9
03	9
04	39
05	133
06	1
07	1
08	743
09	7
10	11
11	11
12	9
13	9
14	674
15	85

15  
connected  
components

# Next Lecture

- Image segmentation
- Reading
  - Chapter 10: Image segmentation I: edge detection, thresholding, and region detection
    - Sections 10.1, 10.2, and 10.3